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[0011] In fabrication a flip-chip bond structure, the fabrication process requires a tight control of interface processes and manufacturing parameters in order to meet very small dimensional tolerances. Various techniques may be utilized to fabricate a UBM structure and to deposit the solder bump. A few widely used methods of depositing bumps include evaporation, electroplating, electroless plating and screen-printing. Kung et al, U.S. patent No. 6,179,200 provides a description of these more widely used methods of depositing bumps as follows.

[0012] The formation of solder bumps can be carried out by an evaporation method of Pb and Sn through a mask for producing the desired solder bumps. When a metal mask is used, UBM metals and solder materials can be evaporated through designated openings in the metal mask and be deposited as an array of pads onto the chip surface.

[0013] In the evaporation method, a wafer is first passivated with an insulating layer, via holes are then etched through the wafer passivation layer which is normally  $\text{SiO}_2$  to provide a communication path between the chip and the outside circuit. After a molybdenum mask is aligned on the wafer, a direct current sputtering cleans the via openings formed in the passivation layer and removes undesirable oxides. A cleaned via opening assures low contact resistance and good adhesion to the  $\text{SiO}_2$ . A chromium layer is evaporated through a metal mask to form an array of round metal pads each covering an individual via to provide adhesion to the passivation layer and to form a solder reaction barrier to the aluminum pad underneath. A second layer of chromium/copper is then co-evaporated to provide resistance to multiple reflows. This is followed by a final UBM layer of pure copper which forms the solderable metallurgy. A thin

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layer of gold may optionally be evaporated to provide an oxidation protection layer. These metal-layered pads define the solder wettable regions on the chips, which are commonly referred to as the ball limiting metallurgy (BLM) or under bump metallurgy (UBM). After the completion of UBM, solder evaporation occurs through a metal mask, which has a hole diameter slightly greater than the UBM mask-hole diameter. This provides the necessary volume for forming a subsequent solder ball. A solder reflow process is performed at a temperature of about 350 degrees Celsius to melt and homogenize the evaporated metal pad and to impart a truncated spherical shape to the solder bump. The evaporation method, even though well established and has been practiced for a long time in the industry, is a slow process and thus can not be run at a high throughput rate.

[0014] A second method for forming solder bumps is the electroplating method. In an electroplating process, UBM layers are first deposited, followed by the deposition of a photoresist layer, the patterning of the photoresist layer, and then the electro-deposition of a solder material into the photoresist openings. After the electro-deposition process is completed, the photoresist layer can be removed and the UBM layers can be etched by using the plated solder bumps as a mask. The solder bumps are then reflowed in a furnace reflow process. The photolithography/electroplating technique is a simpler technique than evaporation and is less expensive because only a single masking operation is required. However, electroplating requires the deposition of a thick and uniform solder over a hole wafer area and etching metal layers on the wafer without damaging the plated solder layer. The technique of electroless plating may also be used to form UBM structure.

**[0015]** Another solder bump formation technique that is capable of solder-bumping a variety of substrates is a solder paste screening method. The screen printing technique can be used to cover the entire area of an 8-inch wafer. In this method, a wafer surface covered by a passivation layer with bond pads exposed is first provided. UBM layers are then deposited on top of the bond pads and the passivation layer. After the coating of a photoresist layer and the patterning of the layer, the UBM layers are etched followed by stripping off the photoresist layer. A stencil is then aligned on the wafer and solder paste is squeegeed through the stencil to fill the openings on top of the bond pads and the UBM layers. After the stencil is removed, the solder bumps may be reflowed in a furnace to form solder balls.

**[0016]** One drawback of the solder paste screen printing process is that, with the recent trend in the miniaturization of device dimensions and the reduction in bump to bump spacing (or pitch), the prior art solder paste screening techniques become impractical. For instance, one of the problems in applying solder paste screening technique to modern IC devices is the paste composition itself. A paste is generally composed of a flux and solder alloy particles. The consistency and uniformity of the solder paste composition becomes more difficult to control with a decreasing solder bump volume. A possible solution for this problem is the utilization of solder paste that contains extremely small and uniform solder particles. However, this can only be achieved at a very high cost penalty. Another problem is using the solder paste screening technique in modern high-density devices is the reduced pitch between bumps. Since there is a large reduction in volume from a paste to the resulting solder bump, the screen holes must be significantly larger in diameter than the final bumps. It is therefore generally desirable to form